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Game Analysis on Local Governments in Combined Management ANP of China

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Abstract

Based on the characteristics of agricultural non-point pollution(ANP), it is pointed out that local governments plays important roles of in ANP. Complete information static game model was used to analyze the input in the pollution. The conclusion was that when local governments with personal rationality came to Nash equilibrium, the total input was less than that with overall rationality in Pareto optimal state. In order to treat agricultural non-point pollution together and reach Pareto optimal state with overall rationality, the thesis analyzed the power, procession and security mechanism seriously.

Key words: ANP(Agricultural non-point pollution), Local governments, Combined managemen

1. Introduction

With the expansion of the regional economy, and promotion of industrialization and urbanization, the development of agricultural non-point source pollution will be aggravated. Non-point pollution is the environmental pollution with no fixed sewage outfall. Agricultural non-point pollution is the water, soil and air pollution caused by the pollutants without treatment in agriculture and lives. They are: (1)Agricultural pollutant source, including water loss and soil erosion, the application of pesticides and chemical fertilizers, animal dung in rural areas, rural domestic sewage, solid waste and agricultural production waste. (2) Forestry pollutant sources include road maintenance and use, deforestation, fertilizer use, burning of the grass on waste land and so on. (3) Mine sources pollutants, brought about by as a result of mining slag, particulate matter, as well as wastewater. (4) Sources of atmospheric deposition are the acids, toxic metals, organic substances and nitrogen and phosphorus caused by atmospheric events. In these pollutant sources, agricultural sources of pollution are in the largest scope, deepest extent and

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broadest distribution. Agricultural non-point source pollution has the characteristics of uncertain time, uncertain means and uncertain number.

In the reform process of decentralization of the Chinese Government, local governments are increasingly becoming independent from the main economic benefits bodies. They are responsible for the development of local economies and protect the functions of the local welfare. They can not be replaced with a decisive role in the ANP. The thesis mainly makes analysis their behavior characters in ANP control. Game theory is used in analyzing strategies of the pollution control. At last, it finds out the power, process and safeguard mechanisms from the perspective of local governments in pollution treatment.

2. Local authority's behavior characteristic in management ANP

2.1. Characteristic of short-term goal behaviors

Under the current local authority achievements inspection system, the local authorities mainly pay attention to the economic growth in short-term. This not only may manifest their achievements, but also bring promotion opportunity directly. However, if the governments don't attach importance to the environment of agriculture, there will be negative externality to economy development and negative influence to the political officials. Therefore, non-point pollution treatment is the least important one of multi-targets for them. When it collides with other targets, local governments of course will choose the one which brings them maximized benefits.

2.2. Rent-seeking activity characters of local governments

Agricultural non-point pollution in general has the characteristics of cross-regional administrative. For the lack of the agricultural non-point source pollution control laws and regulations, decentralized political system makes the measures and oversight mechanisms of administrative constraints of local governments. All these provide the rent-seeking possibility for local governments. The rent-seeking activities can be divided into rent-seeking beforehand and rent-seeking afterward. Rent-seeking beforehand is to influence the regulations and policies benefiting the local non-point pollution treatment in order to obtain matching funds. Rent-seeking afterward is to make revenue under the defective treatment mechanism of agricultural non-point pollution. Both forms influence the investment and control effective dramatically.

2.3. Local governments' free-riding behaviors

With the attention and regulation from central government in ANP, there are different regulation organizations in diverse administrative regions. However, under China's inter-district division of administration; it is difficult to form a formal system of binding rules of local governments' conduct. It will bring larger obstacles for the mechanism supply and innovation.

It is generally believed that the more developed regional economy is and the more revenue the region get, the higher attention and input local government will place in ANP. However, the ANP control is not directly related to local government revenue. While it is related to environment concept and revenue from pollution-free agriculture and green agriculture.

3. Local governments' game behavior in ANP source pollution control

Suppose that there are n local governments controlling agricultural non-point pollution together, g_i is the input of the local government i. In order to discuss conveniently, it is supposed that all governments

input the same in the pollution, therefore, the total input in pollution treatment is $G=\sum g_i$. The bigger G is, the more effective the treatment is, the more revenue the governments can get.

3.1. Nash equilibrium dominated by individual rationality

Suppose that the input of local governments is divided into two items, g_i is the input of agricultural non-point pollution control, x_i represents other inputs. $u_i(x_i,G)$ is the utility function of local government i, and $\frac{\partial u_i}{\partial x_i}>0, \frac{\partial u_i}{\partial G}>0$. Meanwhile, the input in non-pollution and non-point pollution control are marginal substitution decrease. p_x represents the unit cost in non-pollution control, p_G is the unit cost of non-point pollution control(including strategy costs, implementation costs, environmental remediation costs). M_i is the total input in agriculture of local governments. Each local government will face the problems: if other governments' choices have been given, (x_i, g_i) will be chosen, and make the local governments' utility maximized under budget constraints.

$$\begin{aligned} &\max u_i(x_i,G) \\ &st. p_x x_i + p_G g_i \le M_i \end{aligned} \quad (1)$$

Lagrange Function: $L_i = u_i(x_i,G)+\lambda(M_i - p_x x_i + p_G g_i)$, λ is Lagrange multiplier (2)

$$\text{get} \quad \frac{\partial u_i/\partial G}{\partial u_i/\partial x_i} = \frac{p_G}{P_x} \quad (3)$$

Under Nash Equilibrium, the best choice for each local government is the marginal substitution of non-point pollution and non-pollution control equals to input cost per unit. When each government chooses in this way, Nash Equilibrium can be formed. It is named that the total input equilibrium in non-point pollution control without outer constraints is:

$$g^* = (g^*_1,\cdots,g^*_i,\cdots g^*_n), G^* = \sum g_i \quad (4)$$

If the supposed utility functions of local government i:

$$u_i(x_i,G) = x_i^{\alpha} G^{\beta}, 0\le\alpha\le 1, 0\le\beta\le 1, \alpha+\beta\le 1 \quad (5)$$

Then the equilibrium constraint is: $$\frac{\beta x_i^{\alpha} G^{\beta-1}}{\alpha x_i^{\alpha-1} G^{\beta}} = \frac{p_G}{Px} \quad (6)$$

Put the constraint into the formula, get the function:

$$g_i^* = \frac{\alpha}{\alpha+\beta}\frac{Mi}{p_G} - \frac{\alpha}{\alpha+\beta}\sum_{i\ne j} g_i, i = 1,2,3\cdots,n \quad (7)$$

The response function indicates "individual rationality" in the process of ANP control of local governments. That is, each local governments involved in joint management of ANP who want the "free rider" behavior caused the lack of capital investment. Thereby it reduces the effective in ANP control.

3.2. Pareto optimal dominated by overall rationality

Supposed the total welfare function in regional agriculture production environment is $W=\gamma_1 u_1+\gamma_2 u_2+\cdots+\gamma_n u_n$, γ_i is the weight, and $\gamma_i \ge 0$. The total constraint is:

$$\sum_{i=1} Mi = p_x \sum_{i=1} x_i + p_G G \quad (8)$$

Here, it is supposed that the control target is to make total welfare in agriculture production environment maximized. The Lagrange function is:

$$L = \gamma_1 u_1 + \gamma_2 u_2 + \cdots + \gamma_n u_n - \lambda \left(\sum_{i=1} M_i = p_x \sum_{i=1} x_i - P_G G\right), \quad \lambda \text{ is Lagrange multiplier} \quad (9)$$

Then the Pareto Optimal First-order condition is:

$$\sum_{i=1}^{n} r_i \frac{\partial u_i}{\partial G} - \lambda p_G = 0, r_i \frac{\partial u_i}{\partial x_i} - \lambda p_x = 0, 1, 2, 3 \cdots, n \quad (10)$$

The total Parato optimality constraints in agricultural non-point pollution control are:

$$\sum_{i=1}^{n} \frac{\partial u_i / \partial G}{\partial u_i / \partial x_i} = \frac{p_G}{Px} \quad (11)$$

It can be seen that the overall rational-dominated Pareto optimal conditions require the sum of marginal substitution of pollution control and other production input equals to the ratio of unit cost. However, it is supposed that local governments provide pollution control without external constraint. Therefore, the Parato optimality dominated by overall rationality is not the realistic balance.

3.3. Comparative analysis

It is supposed that the utility function of each local government is the same as formula (5), and all agricultural budgets is M. Then the government provides the same input in pollution under individual rationality, the response function (7) can be modified to:

$$gi^* = \frac{\alpha}{\alpha + \beta} \frac{M}{p_G}, i = 1, 2, \cdots, n \quad (12)$$

Then the total input of pollution under Nash Equilibrium with individual rationality is:

$$G^* = n g_i^* = \frac{n\alpha}{n\alpha + \beta} \frac{M}{p_G}, i = 1, 2, \cdots, n \quad (13)$$

While the Parato optimal first order constraint under overall rationality (8-17) transfers to:

$$n \frac{\beta x_i^{\alpha} G^{\beta - 1}}{\alpha x_i^{\alpha - 1} G^{\beta}} = \frac{p_G}{P_X} \quad (14)$$

Put the total constraint in, we can get the optimal construction and total input in agricultural non-point pollution of single local government: $gi^{**} = \frac{\beta}{\alpha + \beta} \frac{M}{P_G}, i = 1, 2, 3 \cdots, n;$ (15)

$$G^{**} = n g_i^{**} = \frac{n\beta}{\alpha + \beta} \frac{M}{p_G}, i = 1, 2, 3, \cdots, n \quad (16)$$

The ratio of input under individual rationality and total rationality is:

$$\frac{G^*}{G^{**}} = \frac{\alpha + \beta}{n\alpha + \beta} < 1 \quad (17)$$

It can be seen that total pollution control input in Nash Equilibrium with individual rationality is less than that of Parato optimality with total rationality.

3.4. Behavior power analysis in ANP joint treatment of local government

Local governments' cooperation needs the driving force from outside. Their cooperation depends on interests or arrangements from the central government. (1) Green GDP must be used to reflect the interaction between economy and environment as one of the important indicators in sustainable development. The central government should perform the appraisal of regional pollution joint control.(2) The establishment of ANP Compensation Mechanism.It refers to the financial allocations, subsidies and the development of related laws and regulations policy from central government and local governments. local governments should be the main investment bodies in ANP compensation and control mechanism.(3)Induced policy.The central government can make use of measures, including the market price regulation, tax regulation or economic incentives policies, etc. through the impact of the costs and benefits to encourage interaction among local government management of ANP.

4. Conclusion

From the analysis above, it is easier to come to the conclusion that under the hypothesis of increasing input in ANP from other local governments and central government, the local government will invest little in current period. Dominated by reasonableness, the two parties in the game tend to form a non-cooperative game, and ultimately go into the plight of prisoners. Pareto optimality in the overall rational-dominated needs external mechanism as the constraint condition. It also needs the joint management of local governments. As can be seen from the game model, the Nash Equilibrium dominated by the individual government is under the current performance appraisal system. The total input for ANP control is less than that of Pareto optimality under overall rational domination. The joint management of the ANP needs to determine the scope accurately and reach a collective decision to build the maintain linkage mechanism. The local government should first give full play to promote the formation of dynamics of innovation in green supply chain and correct market failures, and then set up policies to promote the formation of policies' induced mechanism and Co-management mechanism of different regions local government.In the end, it must provide a symbiotic environment constituted by the government, social organizations, the public, market, science and technology.

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